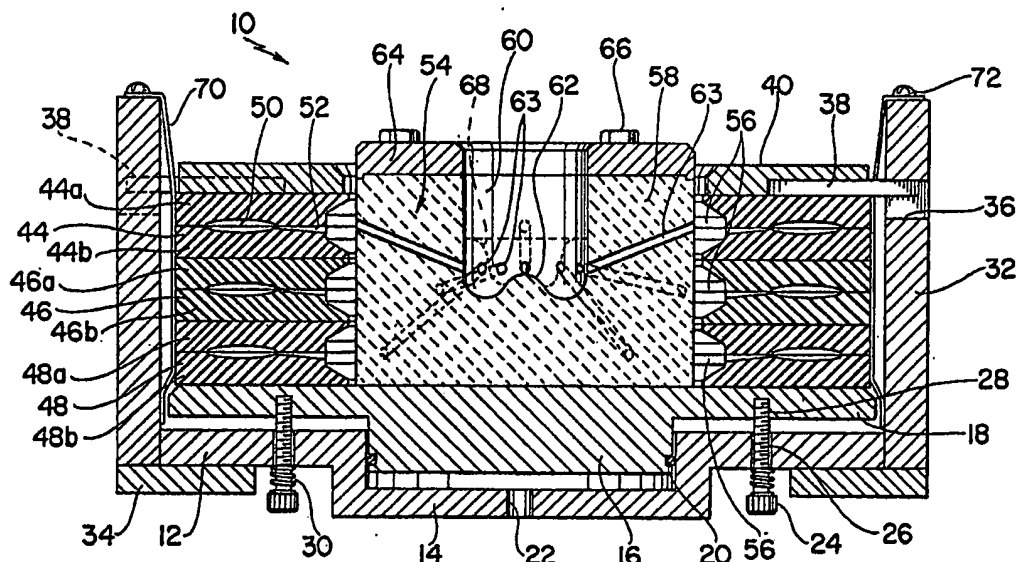




## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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(54) Title: MULTI-MOLD CENTRIFUGAL CASTING APPARATUS



## (57) Abstract

Multi-mold centrifugal casting system comprising basically conventional centrifugal casting apparatus (10) except that instead of receiving a single mold, i.e., one pair of mold halves, a plurality of molds (44, 46 and 48) are mounted in the apparatus (10) in stacked relation, with all mold halves (44a and 44b, 46a and 46b, and 48a and 48b), having central openings to define a plurality of ring-like molds (44, 46 and 48). A manifold member (54) is positioned in the center of the stacked ring-like molds (44, 46 and 48) for receiving and simultaneously feeding molten metal to each of the stacked molds (44, 46 and 48).

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## 1     MULTI-MOLD CENTRIFUGAL CASTING APPARATUS

## 2     Background of the Invention

3           The present invention relates generally to  
4     centrifugal casting apparatus, and is particularly  
5     concerned with the type of apparatus wherein molds of  
6     rubber or the like are positioned in centrifugal casting  
7     machines so as to cast small metallic parts, such as  
8     jewelry and the like.

9           Centrifugal casting utilizing rubber molds is  
10    extremely old and well known, particularly in the jewelry  
11    field. The molds, which are constructed of a rubber-like  
12    material, such as natural rubber, silicone, SBR, or the  
13    like, traditionally comprise two circular mold halves  
14    having mold cavities and radially extending gates formed  
15    on their abutting surfaces so that when the mold halves  
16    are clamped together in the casting machine, said  
17    abutting surfaces cooperate with each other to define the  
18    desired mold cavities with gates extending radially  
19    inwardly from said cavities. In the traditional mold  
20    arrangement, the upper mold half has a circular opening  
21    at its central portion, while the lower mold half  
22    comprises a complete disc, i.e., it has no such central  
23    opening. The mold halves are positioned in the casting  
24    machine with the working surfaces thereof in abutting  
25    relationship with the mold halves positioned between a

1     movable piston plate and a pressure plate, whereby  
2     movement of the piston plate by pneumatic power means or  
3     the like clamps the two mold halves against said pressure  
4     plate whereupon said mold halves are tightly clamped  
5     against each other. Locating means are provided on the  
6     inner working surfaces of the mold halves to insure  
7     proper orientation of one half with respect to the other.  
8     At this point, and with the machine spinning or rotating  
9     by conventional drive means, molten metal is poured,  
10    usually manually, into the space defined by the central  
11    opening of the upper mold half, whereupon centrifugal  
12    force causes the molten metal to flow radially outwardly  
13    through the radially extending gates to the mold cavities  
14    until said cavities are completely filled with the molten  
15    metal. At this point the metal is allowed to solidify,  
16    the molds are separated, and the castings are removed  
17    therefrom, after which the gate castings are broken away  
18    from the cast articles, and the latter are then finished  
19    by conventional techniques to remove surface  
20    irregularities and the like. This process has long been  
21    used in the jewelry industry to produce relatively  
22    inexpensive jewelry castings of so-called white metal,  
23    although other alloys can be used.  
24            Although generally satisfactory, the above described  
25    centrifugal casting process has a number of dis-

1 advantages. First of all, to insure proper casting, sub-  
2 stantial clamping pressure must be applied to the mold  
3 halves, which pressure, because of the rubber-like  
4 material of which the molds are made, results in some  
5 degree of distortion of the mold cavities. This  
6 distortion is somewhat amplified by the relatively high  
7 rotational speed that is required to insure sufficient  
8 centrifugal force to fill the mold cavities. Obviously  
9 this distortion of the mold cavities results in  
10 comparable distortion of the cast parts which, of course,  
11 is highly undesirable, and while such distortion may be  
12 something that one can live with when dealing with  
13 relatively inexpensive cast jewelry, it effectively  
14 prevents mechanical parts having any kind of precision  
15 requirements, such as nuts and bolts, for example, from  
16 being satisfactorily made by the centrifugal casting  
17 process.

18 In addition, a common problem with rubber molds of  
19 this type is so-called "flashing", i.e., erosion of the  
20 surfaces of the molds adjacent the mold cavities which  
21 permits small amounts of molten metal to be forced  
22 outwardly from the mold cavities between the mold halves.  
23 It is conventional to minimize this "flashing" phenomenon  
24 by placing shims at the outer surfaces of the mold halves

1 to increase the clamping pressure at those areas of the  
2 mold where "flashing" is taking place.

3 Another problem is that the mold cavities must be  
4 back-vented, i.e., vents must be provided to receive the  
5 air that is forced out of the mold cavities when the  
6 molten metal flows therein.

7 Aside from distortion, "flashing", and back-venting,  
8 conventional rubber molds for centrifugal casting require  
9 a substantial degree of skill from the person operating  
10 the casting machine. More specifically, proper clamping  
11 pressure must be applied to the mold halves, appropriate  
12 shims must be inserted, and the rotational speed of the  
13 casting machine is quite critical, as is the amount of  
14 molten metal that is manually poured into the mold.  
15 Thus, the effectiveness of the conventional centrifugal  
16 casting process is to a large extent dependent on the  
17 skill of the particular operator involved.

18 Finally, since it has heretofore been conventional  
19 to place only one mold in the casting machine for each  
20 molding operation, the time required to produce the  
21 desired number of cast parts is necessarily magnified.

1     **Summary of the Invention**

2             The basic and salient concept of the present  
3     invention is the provision of modified rubber molds  
4     whereby a plurality of such molds may be positioned in  
5     the casting machine in stacked relation, with means for  
6     receiving and simultaneously feeding the molten metal to  
7     each mold. Thus, if three molds are positioned in the  
8     casting machine, the production output will be three  
9     times as great. Therefore, a primary object and  
10    advantage of the present invention is to increase the  
11    production capacity of the casting apparatus, with only  
12    minor changes having to be made to conventional  
13    apparatus, although, as aforesaid, the rubber molds are  
14    somewhat different than the presently existing rubber  
15    molds. Specifically, in the present invention, both the  
16    upper and lower mold halves are provided with openings at  
17    their central portion wherein the entire mold comprises  
18    a ring-like configuration. This permits a plurality of  
19    these ring-like molds to be stacked upon each other, and  
20    a manifold member is positioned in the center space of  
21    the stacked molds for receiving and feeding the molten  
22    metal simultaneously to each mold.

23             In addition to the obvious increase in production  
24    capacity that results from the present invention, it has  
25    also been found that the stacked ring-like molds of the

1 present invention require less clamping pressure and less  
2 rotational speed during the casting operation, thus  
3 greatly minimizing the distortion and "flashing" that  
4 takes place. Also, the reduction in clamping pressure  
5 greatly reduces back-venting requirements, thus making  
6 the molds easier to make. Further, the criticality of  
7 clamping pressure, rotational speed, and amount of molten  
8 metal poured into the molds no longer exists, thus,  
9 permitting even an unskilled operator to effectively  
10 operate the casting apparatus of the present invention.

11 Thus, the primary object of the present invention is  
12 to provide a novel centrifugal casting system embodying  
13 novel rubber molds that result in greatly increased pro-  
14 duction capacity, as well as greatly improved cast parts.

15 Other objects, features and advantages of the  
16 invention shall become apparent as the description  
17 thereof proceeds when considered in connection with the  
18 accompanying illustrative drawings.

19

20 **Description of the Drawing:**

21 In the drawing which illustrates the best mode  
22 presently contemplated for carrying out the present  
23 invention:



1           Fig. 1 is a top plan view of centrifugal casting  
2           apparatus embodying the present invention with a portion  
3           broken away for purposes of illustration; and

4           Fig. 2 is a section taken on line 2-2 of Fig. 1.

5

6           **Description of the Preferred Form of the Invention**

7           Referring to the drawings, and more particularly  
8           Fig. 2, centrifugal casting apparatus is shown generally  
9           at 10 comprising a circular fixed based plate 12 having  
10          a stepped depending central portion 14 which receives  
11          depending central portion 16 of piston plate 18 in  
12          sliding relation with an O-ring 20 providing a sliding  
13          seal between the portions 14 and 16. A port 22 is  
14          provided in portion 14 through which pressurized air may  
15          be introduced by means of any suitable pneumatic  
16          apparatus so as to force piston plate 18 in an upward  
17          direction for reasons which will hereinafter become  
18          apparent. Studs 24 having threaded shanks 26 extend  
19          freely and slidably through base 12 and are threadedly  
20          received in plate 18 as at 28. Springs 30 positioned  
21          between the lower surface of plate 12 and the heads of  
22          studs 24 normally bias piston plate 18 to its downward or  
23          inoperative position, it being understood that when  
24          pressurized air is introduced through port 22, piston 18

1 is forced to move upwardly against the bias of the  
2 springs 30.

3 A plurality of upright stanchions 32, preferably  
4 four in number spaced approximately 90° from each other,  
5 extend upwardly from the outer periphery of base  
6 plate 12, said stanchions being secured to base plate 12  
7 by flanges 34 that extend beneath base plate 12, said  
8 flanges being secured to stanchions 32 and to base  
9 plate 12 by any suitable means, such as screws or the  
10 like (not shown). Each stanchion has a notch 36 adjacent  
11 to but spaced from its upper extremity, said notches  
12 receiving therein the outer ends of lugs 38 secured to a  
13 circular ring-like pressure plate 40 by any suitable  
14 means, such as screws 42. Positioned between pressure  
15 plate 40 and pressure piston 18 are a plurality of  
16 molds 44, 46 and 48. Said molds are constructed of any  
17 suitable rubber-like or elastomeric material, such as  
18 silicone, SBR, natural rubber, or the like, the sole  
19 requirement of said material being that it be  
20 sufficiently flexible and that it be able to withstand  
21 the heat of the molten metal to which it is exposed. It  
22 will therefore be understood that when reference is  
23 hereinafter made to "rubber molds", the term is being  
24 used broadly to cover all equivalent elastomeric  
25 materials. Each of the molds 44, 46 and 48 comprises

1 upper mold halves 44a, 46a, and 48a, as well as lower  
2 mold halves 44b, 46b, and 48b. The inner abutting  
3 surfaces of each of said mold halves are provided with  
4 mold cavities 50 from which gates or passages 52 extend  
5 radially inwardly. It is important to note that all of  
6 said mold halves are ring-like members having open  
7 central portions of the same diameter, whereby when said  
8 molds are stacked one upon the other, a central space is  
9 provided for receiving a manifold member shown generally  
10 at 54. Specifically, the stacked molds, as well as  
11 manifold member 54, are positioned on the top surface of  
12 piston plate 18, and then after the plurality of molds  
13 have been so positioned, annular pressure plate 40 is  
14 positioned on top of the uppermost mold half 44a and is  
15 then slightly rotated so that lugs 38 engage within  
16 notches 36 on the stanchions 32. This interengagement or  
17 locking action limits upward movement of plate 40,  
18 whereupon introduction of pneumatic pressure through  
19 port 22 causes piston plate 18 to move upwardly to the  
20 position illustrated in Fig. 2, in which position the  
21 molds 44, 46 and 48 are clamped between plates 18 and 40  
22 with the desired amount of pressure, which pressure is  
23 approximately 25% of the clamping pressure required to  
24 properly clamp the upper and lower halves of conventional  
25 rubber molds now in existence. In addition, the

1 apparatus 10, which is rotated by any conventional means  
2 (not shown) need only be rotated at approximately one-  
3 half the speed that is required for conventional single-  
4 mold casting machines now in existence. This reduction  
5 in clamping pressure and rotational speed minimizes  
6 distortion of the mold cavities, minimizes "flashing",  
7 and reduces or entirely eliminates the need for back-  
8 venting.

9 It is important to note that the inner edges of  
10 molds 44, 46 and 48 are provided with an annular  
11 recess 56, a portion of which is formed in the upper mold  
12 half and the remaining portion in the lower mold half,  
13 whereupon when the two mold halves are in aligned  
14 abutting relation, the annular recess 56 automatically  
15 results. Also, as will be evident from Fig. 2, all of  
16 the molds are of the same size and configuration, whereby  
17 the molds can be stacked in any order.

18 Manifold member 54 comprises a cylindrical  
19 housing 58 preferably constructed of a ceramic material,  
20 said housing having a center well 60, the bottom surface  
21 of which is of undulating configuration as a result of  
22 having a central hump 62 thereon. A plurality of  
23 elongated bores or passageways 63 extend from the inner  
24 wall of well 60 at a height just above the top of hump 62  
25 through the body of said housing into communication with

1 the aforesaid annular recesses 56 at spaced points around  
2 the circumferential extent of said recesses. A hold-down  
3 disc 64 is positioned on the top of housing 58, and  
4 fastening elements such as threaded bolts 66 extend  
5 through disc 64, housing 58, into threaded securement  
6 with piston plate 18 to securely clamp manifold member 54  
7 onto said piston plate.

8 In operation and use, and with the ring molds 44, 46  
9 and 48 clamped between piston plate 18 and pressure  
10 plate 40 with the proper amount of pressure, molten metal  
11 is poured into well 60 while the apparatus 10 is  
12 rotating, as a result of which, and as a result of the  
13 undulated configuration 62 of the bottom wall of the  
14 well, centrifugal force causes the molten metal to assume  
15 a wave-like configuration as shown in broken lines at 68  
16 in Fig. 2, wherein the molten metal has in effect climbed  
17 up the side wall of well 60 to a point well above the  
18 passages 63. Thus, centrifugal force carries the molten  
19 metal through the passages 63 to each of the annular  
20 recesses 56 whereupon the latter become filled with the  
21 molten metal so as to provide a reservoir for feeding the  
22 molten metal to gates 52 and cavities 50, which feeding  
23 action also takes place because of the centrifugal force  
24 that results from the spinning or rotation of  
25 apparatus 10. The important thing here is that the

1 volume of the annular recesses 56 in each mold is greater  
2 than the combined volumes of the cavities 50 and gates 52  
3 in each mold, whereby said recesses 56 insure an ample  
4 supply of molten metal for completely filling each mold  
5 cavity. Since it is important that the annular  
6 recesses 56 be uniform in size throughout their circum-  
7 ferential extent, in order to insure uniform filling of  
8 all the mold cavities, it is important that the molds be  
9 properly centered with respect to the rotational axis of  
10 the apparatus 10. This is achieved by providing spring  
11 arms 70 on each of the stanchions 32, said spring arms  
12 being secured to the top of each stanchion by screws 72,  
13 said spring arms further imparting uniform resilient  
14 pressure to the outer edges of said molds at four  
15 equally-spaced points around the outer circumferences of  
16 said molds so as to retain the molds properly centered.  
17 In addition, where such becomes necessary to insure equal  
18 flow of molten metal to all of the annular recesses 56,  
19 the diameters of the passages 63 can be varied. Also, as  
20 clearly shown in Fig. 2, the innermost circular edges of  
21 molds 44, 46 and 48 are spaced from the outer surface of  
22 cylindrical housing 58. This spacing prevents any back  
23 pressure from building up in the recesses 56 that would  
24 tend to impede outward flow of metal through manifold  
25 passages 63, and also permits upward removal of the molds

1 from apparatus 10 without any frictional binding between  
2 the mold inner edges and cylindrical housing 58.

3 Where white metal is employed as the casting alloy,  
4 which is quite conventional in the jewelry industry, a  
5 skin comprised of tin oxide automatically forms on the  
6 surface of the molten metal, said formation being known  
7 in the industry as "dross", which signifies an accumu-  
8 lation of oxides. During the casting operation, dross  
9 causes discoloration and porosity in the cast parts and  
10 hence is highly undesirable. In the instant invention,  
11 however, it has been found that when the molten metal is  
12 introduced into the central well of the manifold member,  
13 centrifugal force causes the tin oxide, which is lighter  
14 than the alloy, to be forced to the inner surface of the  
15 wave 68 whereby the cleaner alloy goes to the annular  
16 recesses 56 and then to the mold cavities 50 before the  
17 tin oxide surface layer does, thus minimizing the amount  
18 of dross in the cast parts. This, of course, represents  
19 another significant advantage of the present invention.

20 Although the drawings show three ring molds in  
21 stacked relation, it will be understood that this  
22 invention is applicable to two or more of such molds,  
23 although the invention has been found to be particularly  
24 effective where three molds are employed in stacked  
25 relation. Since the reduction in clamping pressure and

1 rotational speed that results from the present invention  
2 minimizes distortion of the mold cavities and hence the  
3 cast parts, it has been found that mechanical parts, such  
4 as nuts and bolts, can now be effectively produced by  
5 centrifugal casting, whereas such has not generally been  
6 heretofore possible. Since my new ring molds permit a  
7 plurality of said molds to be stacked in a single casting  
8 machine, production capacity is increased by a multiple  
9 equal to the number of molds employed. It is also  
10 important to note that the ring molds of the present  
11 invention do not require major modifications to existing  
12 casting apparatus. Aside from the labor saving that  
13 automatically ensues from the increased production that  
14 results from the present invention, the manufacture of  
15 the molds per se is easier and less expensive with the  
16 ring molds of the present invention, because it is no  
17 longer necessary to cut circular reservoirs or back-  
18 venting channels into the molds, it being understood that  
19 the annular recesses on the inner edge of the molds is  
20 automatically formed during the manufacture of the molds.  
21 Also, very little skill on the part of the operator is  
22 required to effectively operate the multi-mold system of  
23 the present invention. Virtually all the operator has to  
24 do is to pour the molten metal into the central well of  
25 the manifold, whereas in the conventional single-mold



1 centrifugal casting system, the precise clamping pressure  
2 of the mold halves is much more critical, shimming of the  
3 molds is frequently required, and the amount of molten  
4 metal poured into the mold is also a factor of  
5 importance. One further advantage of my novel and  
6 improved system is the fact that the uniformity of the  
7 central circular gate that is attached to the radial  
8 gates and the cast parts when the latter are removed from  
9 the molds makes it possible to use automated means for  
10 checking the cast parts for defects.

11 While there is shown and described herein certain  
12 specific structure embodying the invention, it will be  
13 manifest to those skilled in the art that various  
14 modifications and rearrangements of the parts may be made  
15 without departing from the spirit and scope of the  
16 underlying inventive concept and that the same is not  
17 limited to the particular forms herein shown and  
18 described except insofar as indicated by the scope of the  
19 appended claims.

**What is claimed is:**

1           1. In centrifugal casting apparatus of the type  
2           comprising a fixed base, a piston plate mounted on said  
3           base for receiving thereon a rubber mold comprising face-  
4           to-face mold halves having cooperating mold cavities and  
5           radially extending gates on their abutting surfaces, and  
6           a fixed pressure plate engaging the top of said mold  
7           whereby movement of said piston toward said pressure  
8           plate causes clamping of said mold halves against each  
9           other, the improvement comprising a plurality of said  
10          molds mounted on said piston plate in stacked relation,  
11          all of said mold halves being open at their center  
12          portions to define ring-like mold members having inner  
13          and outer concentric circular edges, and means positioned  
14          in the center of said stacked ring-like mold members for  
15          receiving and simultaneously introducing molten metal to  
16          the gates of each of said molds while the apparatus and  
17          molds are rotating.

1           2. In the apparatus of claim 1, each of said molds  
2           having an annular recess provided on its inner edge so as  
3           to form a reservoir for receiving a supply of molten  
4           metal from said introducing means.

1           3. In the apparatus of claim 1, said receiving and  
2     introducing means comprising a cylindrical manifold  
3     having a central well for receiving said molten metal,  
4     and passages extending from said central well to the  
5     outer surface of said manifold with some of said passages  
6     terminating adjacent the inner edge of each of said  
7     molds, whereby centrifugal force simultaneously carries  
8     the molten metal from said central well through said  
9     passages to the inner edge of each of said molds, and  
10    then through said gates to said mold cavities.

1           4. In the apparatus of claim 3, each of said molds  
2     having an annular recess provided on its inner edge so as  
3     to form a reservoir for receiving a supply of molten  
4     metal from said passages.

1           5. In the apparatus of claim 3, said central well  
2     having an undulated bottom wall, said undulation  
3     comprising a centrally positioned hump.

1           6. In the apparatus of claim 4, said central well  
2     having an undulated bottom wall, said undulation  
3     comprising a centrally positioned hump.

1           7. The apparatus of claim 1 further comprising  
2 means for centering said molds with respect to the  
3 rotational axis of said apparatus.

1           8. In the apparatus of claim 7, said centering  
2 means comprising portions carried by said fixed base  
3 extending upwardly adjacent the outer edge of said molds,  
4 and spring members carried by said upwardly extending  
5 portions resiliently engaging said outer mold edges at  
6 positions around the periphery thereof.

1           9. A rubber mold for use in centrifugal casting,  
2 said mold comprising a pair of circular face-to-face  
3 halves having on their abutting surfaces cooperating  
4 cavities and gates extending radially inward from said  
5 cavities, each of said mold halves being open at their  
6 center portion to define ring-like mold members having  
7 inner and outer concentric edges.

1           10. The rubber mold of claim 9 further  
2 characterized in that said inner mold edge is provided  
3 with an annular recess.

1           11. The rubber mold of claim 10 further  
2 characterized in that the volume of said annular recess  
3 is greater than the cumulative volume of said cavities  
4 and radial gates.

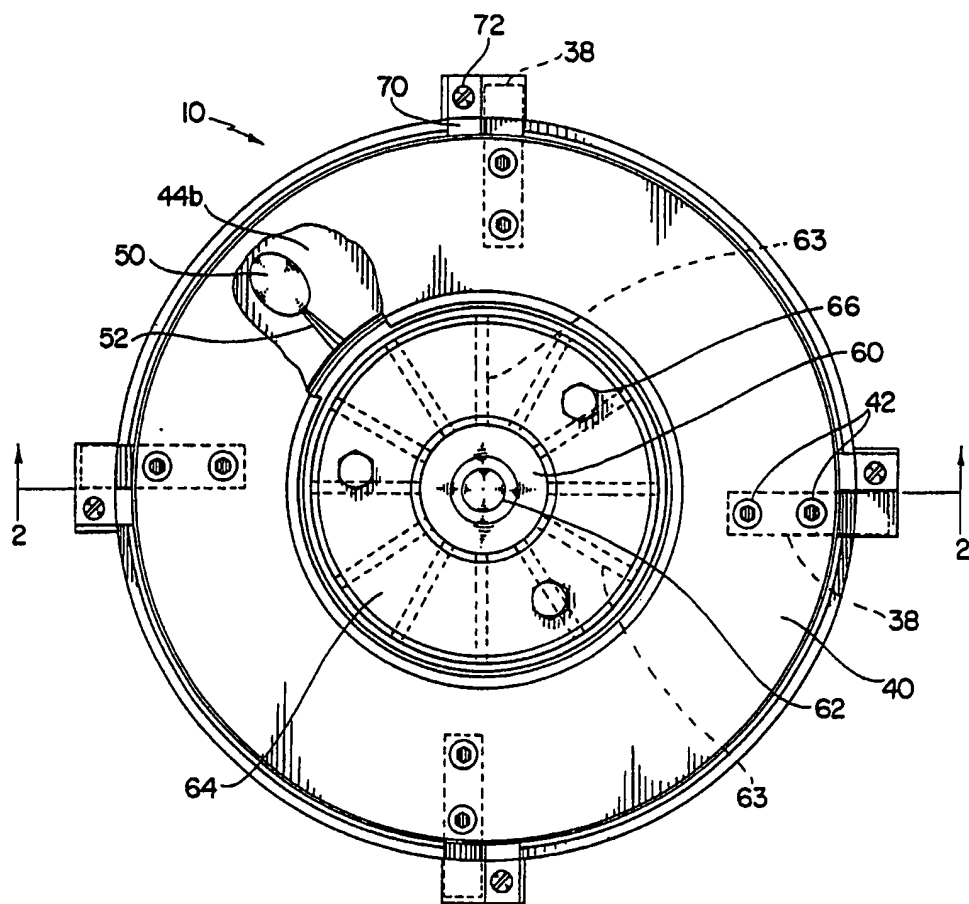


FIG. 1

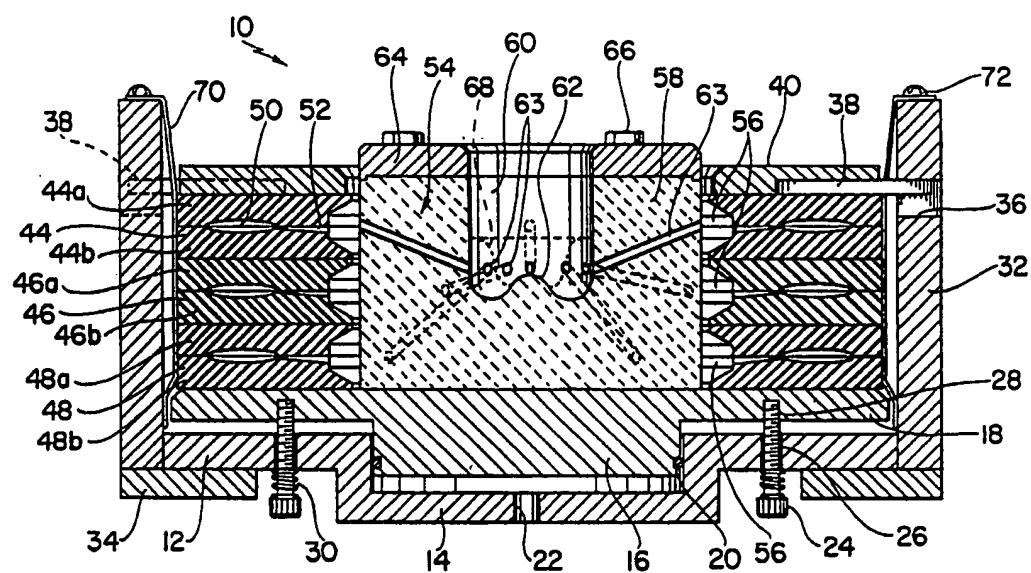


FIG. 2

## INTERNATIONAL SEARCH REPORT

PCT/US92/08598

**A. CLASSIFICATION OF SUBJECT MATTER**

IPC(5) :B22D 13/06

US CL :164/290,292

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 164/290,292 164/6,286,287,289,339

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category*     | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---------------|--|-----------------------|
| <u>X</u><br>Y | US,A, 4,723,904 (Maynard et al.) 09 February 1988                                  | <u>9-11</u><br>1-8    |
| Y             | US,A, 2,811,757 (Banister) 05 November 1957  | 1-8                   |

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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